I. C. 6990

AUGUST 1938

UNITED STATES
DEPARTMENT OF THE INTERIOR
HAROLD L. ICKES, SECRETARY

BUREAU OF MINES
JOHN W. FINCH, DIRECTOR

INFORMATION CIRCULAR

MINING AND MILLING METHODS AND COSTS AT THE SUMMITVILLE CONSOLIDATED MINES, INC., SUMMITVILLE, COLO.

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UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

MINING AND MILLING METHODS AND COSTS AT THE SUMMITVILLE CONSOLIDATED MINES, INC., SUMMITVILLE, COLO. 1/

By Jos. R. Guiteras 2/

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INTRODUCTION

This is one of a series of information circulars describing mining and milling methods being published by the Bureau of Mines. The Summitville Consolidated Mines, Inc., is the only company now active at Summitville. Since the holdings of the company include those of most of the former producers of the camp, the paper virtually becomes a description of the Summitville district. The field data were collected from August 23 to 28, 1937.

ACKNOWLEDGMENTS

The writer gratefully acknowledges his indebtedness to H. F. Detrick, president, and Edward Thornton, general manager of the company for their cooperation in making this paper possible. Most of the information on underground operations was given by Roy Jellison, mine superintendent; the metallurgical data were supplied by Art Carlson, metallurgist, and W. L. Anderson, mill superintendent; much general and technical information was supplied by J. H. Hannan, engineer.

LOCATION

The mines and mill of the Summitville Consolidated Mines, Inc., are at Summitville, a mining camp in the Platoro-Summitville mining district in Rio Grande County in the south-central part of Colorado.

The camp lies at the north foot of South Mountain at an altitude of 11,300 feet, near the head of Wightmans Fork, a branch of the Alamosa River. That part of the Platoro-Summitville mining district adjacent to Summitville is known as the Summitville district. It may be reached by road from Del Norte or from Monte Vista. The Del Norte road is 26 miles long; grades are steep, and in wet weather the surface is dangerously slippery. It is the original road to the camp but is not used much at present. The road from Monte Vista is the main haulage road to and from the camp. It runs south from Monte Vista for 12.5 miles, then westerly 25 miles following the Alamosa River to the mouth of Wightmans Fork, then 6 miles northwesterly up Wightmans Fork to Summitville, a total distance of 43.5 miles.

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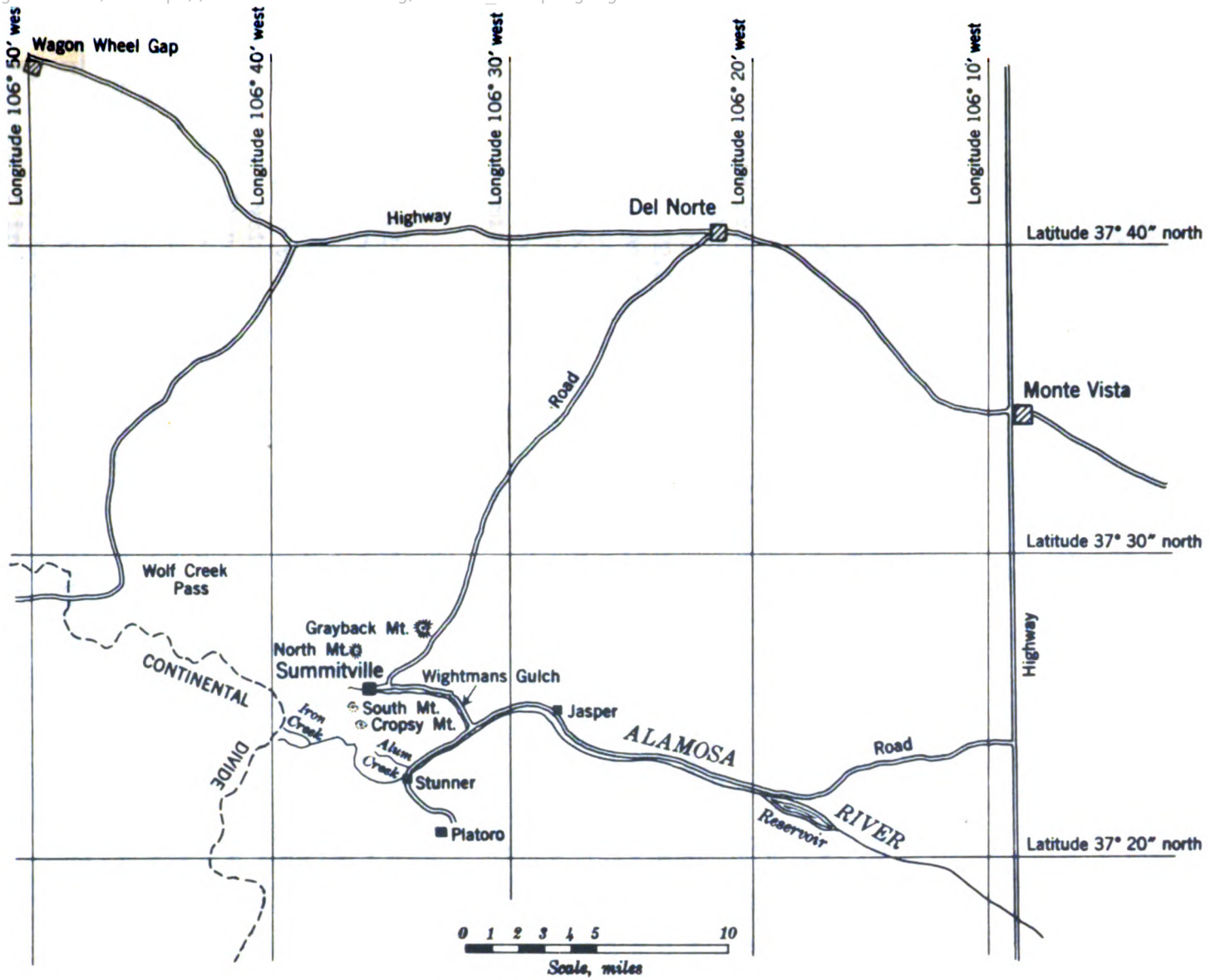

Figure 1.— Map showing location of Summitville district, Colorado. (After Forest Service.)

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Figure 1 shows the location of Summitville with respect to neighboring towns.

TOPOGRAPHY

The Summitville district embraces an area of rugged topography. The highest nearby point is Cropsy Peak, 1 1/2 miles to the south (altitude 12,557 feet). The lowest point is near Jasper, about 7 miles to the east (altitude 9,200 feet). Timber line is at 12,000 feet.

CLIMATE3/

The nearest station of the United States Weather Bureau is at Del Norte, about 20 miles northeast of Summitville (altitude 7,868 feet). The average annual precipitation at Del Norte for an 18-year period was 8.20 inches; the greatest annual precipitation was 12.39 inches in 1929, and the least was 4.76 inches in 1934. The precipitation for 1936 was 9.19 inches, with a maximum monthly precipitation of 3.78 inches in August and a minimum precipitation of less than 0.01 inch in January. At Summitville (altitude 11,300 feet) the precipitation is much greater. This is indicated by records kept from 1889 to 1922 at Platoro, about 7 miles southeast of Summitville (altitude 9,800 feet). The average annual precipitation at Platoro during that period was 31.85 inches; the high was 40.33 inches in 1911; the low, 22.03 in 1910. Enough snow falls on the mountains above Summitville to assure a plentiful supply of water for the camp the year round. A 15-year record of temperatures at Del Norte gives a high normal temperature of 62.0° in July and a low normal temperature of 21.2° in January. In 1936 an extremely high temperature of 88.0° was reached in June and an extreme low of -11.0° in February. Winters are a little warmer at Summitville than at Del Norte; summers are much cooler.

HISTORY4/

Placer gold was first found in Wightmans Gulch in the summer of 1870 by a party of prospectors; desultory sluicing followed. The richest lodes in the district were discovered a few years later near the head of the gulch. All the mines were on one or more of a series of parallel veins that outcrop on the northeast slope of South Mountain. The earliest developments of the veins was by open-cuts that were soon supplemented by shafts and adits. Eleven stamp mills were built from 1874 to 1884 and they proved satisfactory for treating the oxidized ores, which were free-milling. The underlying sulphide ores were not treated successfully for many years. The camp was idle from 1916 to 1926. From 1926 to 1931 several hundred thousand dollars' worth of ore was taken by lessees from the Little Annie

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3/ Climatological data for the United States by sections, Weather Bureau, Department of Agriculture.

4/ Sources of information on early distory of Summitville:
Henderson, Chas. W., Mining in Colorado: Geol. Survey Prof. Paper 138, 1926, pp. 201-206.
Patton, H. B., Geology and Ore Deposits of the Platoro-Summitville Mining District, Colo.: Colorado Geol. Survey Bull. 13, 1917, pp. 65-69.

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group. The sorted ore was shipped to Omaha and Colorado Springs. In 1933, other lessees shipped crude ore from the property. In 1934 the Summitville Consolidated Mines, Inc., was organized. The property comprises about 50 claims, including the Little Annie group, which is responsible for most of the production of the district. Construction of the present concentration-cyanide mill was begun in July 1934 and finished in the following October. The first concentrates were shipped to Leadville November 9, 1934.

GEOLOGY

All the rocks in the Summitville district are igneous, mainly Tertiary extrusives. According to Patton[5], the country rock in the vicinity of the mines on South Mountain is a gray quartz-biotite latite; it occurs as a succession of flows and as dikes cutting the flows. Veins have formed in fractures that roughly parallel the dikes. The country rock near the veins has been extensively altered by kaolinization, sericitization, and silicification. Most of the veins strike N. 30° to 50° W.; some strike nearly west. Dips usually range between 70° and 85° SW., although some veins have dips as low as 45° SW. The most important veins in the district are the Tewkesbury, the Little Annie (called Aztec and Golconda in some of the workings), and the McDonald; they all strike about N. 50° W. and dip at about 85° SW. The Little Annie vein has been the most productive and best exemplifies the characteristics of the veins in the district. A streak of vein quartz 2 to 3 feet wide occupies the center of the vein. On both sides of the quartz core is a zone of quartz that has replaced the minerals (except quartz) of the latite country rock. The width of the quartz replacement vein is very irregular; it ranges from 2 or 3 to about 75 feet. Most of the veins that are now (1937) being worked are narrower than the Little Annie. They range in width up to 25 feet; the average is about 5 feet. The veins have no definite walls.

The only mineral of value is native gold; it occurs irregularly disseminated through the replacement quartz. The width of ore in the veins is therefore extremely irregular. Stope walls are commercial, and close sampling is necessary to distinguish ore from waste. Limonite occurs in the oxidized zone, which extends to a depth of 50 to 300 feet below the surface; pyrite is found below. The best ore is found in the oxidized zone, where the gold is associated with limonite in vug linings.

The ore being mined in August 1937 assayed 0.35 ounce of gold per ton; the minimum grade broken was 0.30 ounce per ton.

TOWNSITES

The main camp at Summitville is shown in figure 2 (a). A mine office building and a warehouse building are on a hillside near the portal of the Reynolds adit. They are 2-story buildings; the upper floors are used for living accommodations. A nurse's office is provided in the warehouse building.

5/ Patton, H. B., work cited.

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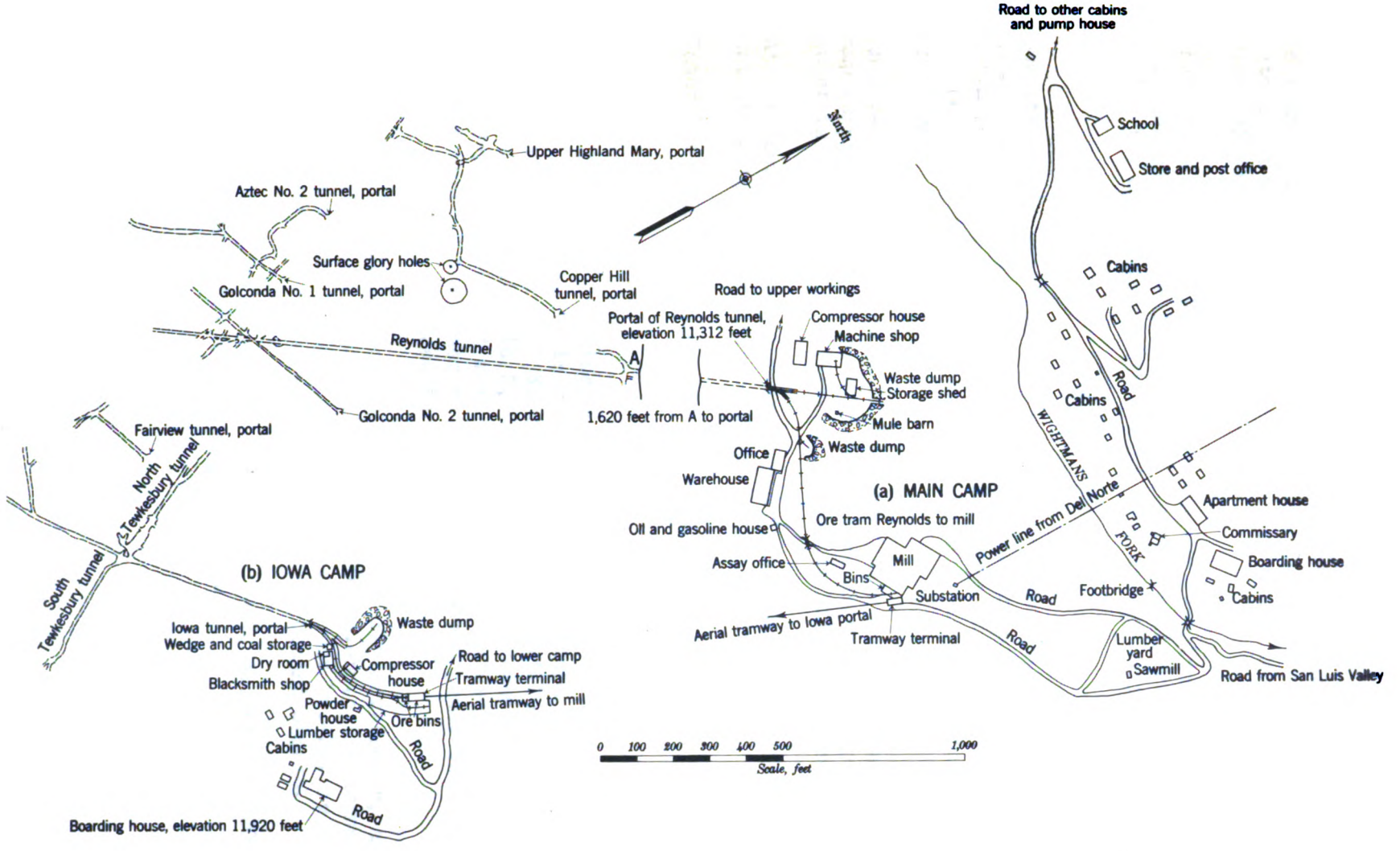

Figure 2.–Surface plans showing buildings at (a) main camp and (b) Iowa camp, and their relation to underground workings.

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The main townsite is across Wightmans Gulch from the adit. The principal buildings are a boarding house, an apartment house, a commissary, a combined store and post office, and a school building. More than 60 cabins of various sizes are clustered nearby.

There is a group of 10 cabins between the Reynolds and Copper Hill portals. The camp at the Iowa portal is shown in figure 2b; it is connected with the main townsite by a dirt road and an aerial tramway.

WATER SUPPLY

Summitville is supplied with water from Wightmans Fork. Two 2-stage centrifugal pumps, each driven by a 20-horsepower motor, deliver the water to two 12- by 20-foot wooden storage tanks above the camp; the pumping head is 160 feet. One of the pumps is used only 16 hours; the other, 24 hours per day.

An air-operated steam pump in the compressor house pumps water from the camp supply line to two 6- by 6-foot tanks above the Copper Hill adit. This water is used for the drills in the Copper Hill workings.

At the Iowa townsite water is pumped from a small tributary creek to a distributing tank in the attic of the boarding house.

Water for milling is taken from the main camp supply.

POWER

Electric power for the mine and mill is purchased from the Public Service Co. of Colorado. It is generated at the Alamosa steam plant and brought to Summitville via Del Norte. At the Summitville substation it is stepped down from 23,000 to 2,300 volts; the compressors and the ball mill are driven by 2,300-volt motors. The voltage is stepped down to 440 volts for most of the other motors; some 220-volt power is used and most 110-volt circuits are used for lighting.

The average demand for both mine and mill is 325 horsepower, and the average monthly power consumption is 240,000 kw.-hr.; the average monthly cost of power is $4,500. The average cost per kw.-hr. is therefore a little under 1.9 cents, which includes the demand charge.

Power consumed from July 20 to August 20, 1937, amounted to 209,360 kw.-hr. It was distributed as shown in table 1.

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TABLE 1. - Distribution of power, July 20 to August 20, 1937

Item	Kw.-hr.	Percent
Mine (including camp):		
Compressors	54,692	26.1
Pumps	14,172	6.8
Battery chargers	1,940	.9
Blower	4,528	2.2
Transformer	8,046	3.8
Shops and bakery	4,282	2.0
Lights	10,279	4.9
Total mine	97,939	46.7
Mill:		
Crushing	7,900	3.8
Grinding	49,532	23.6
Flotation	7,639	3.6
Tables	768	.4
Cyanide	35,908	17.2
High-grade section	949	.5
General, including assay laboratory	8,725	4.2
Total mill	111,421	53.3
Total mine and mill	209,360	100.0

MINE

Surface Plant

A compressor house, machine shop, and storage shed occupy the waste dump of the Reynolds adit. (See fig. 2). An ore tram connects the adit with the mill bins at the top of the mill. The power substation is near the mill, and just beyond is a small saw mill.

The compressor building houses an 18- by 10- by 14-inch compressor, belt-driven by a 100-horsepower motor, and two 16- by 9- by 12-inch compressors, each driven by a 125-horsepower motor by multiple V belt. The three compressors deliver air at a pressure of 100 pounds per square inch to two receivers in the compressor house. One receiver is 4- by 12-feet; the other is 4 by 16 feet. A 6-inch line carries the air to the Dexter adit, whence a 4-inch line runs about 300 feet into the adit to a 4- by 10-foot receiver. In August 1937 another receiver, 4 by 14 feet, was being installed about 800 feet in from the portal. A 4-inch air line extends over the surface from the portal of the Dexter adit to the portal of the Copper Hill adit.

A 6-inch air line extends from the compressor house for a distance of 3,500 feet into the Reynolds adit; a 4- by 10-foot receiver is 3,000 feet in from the portal.

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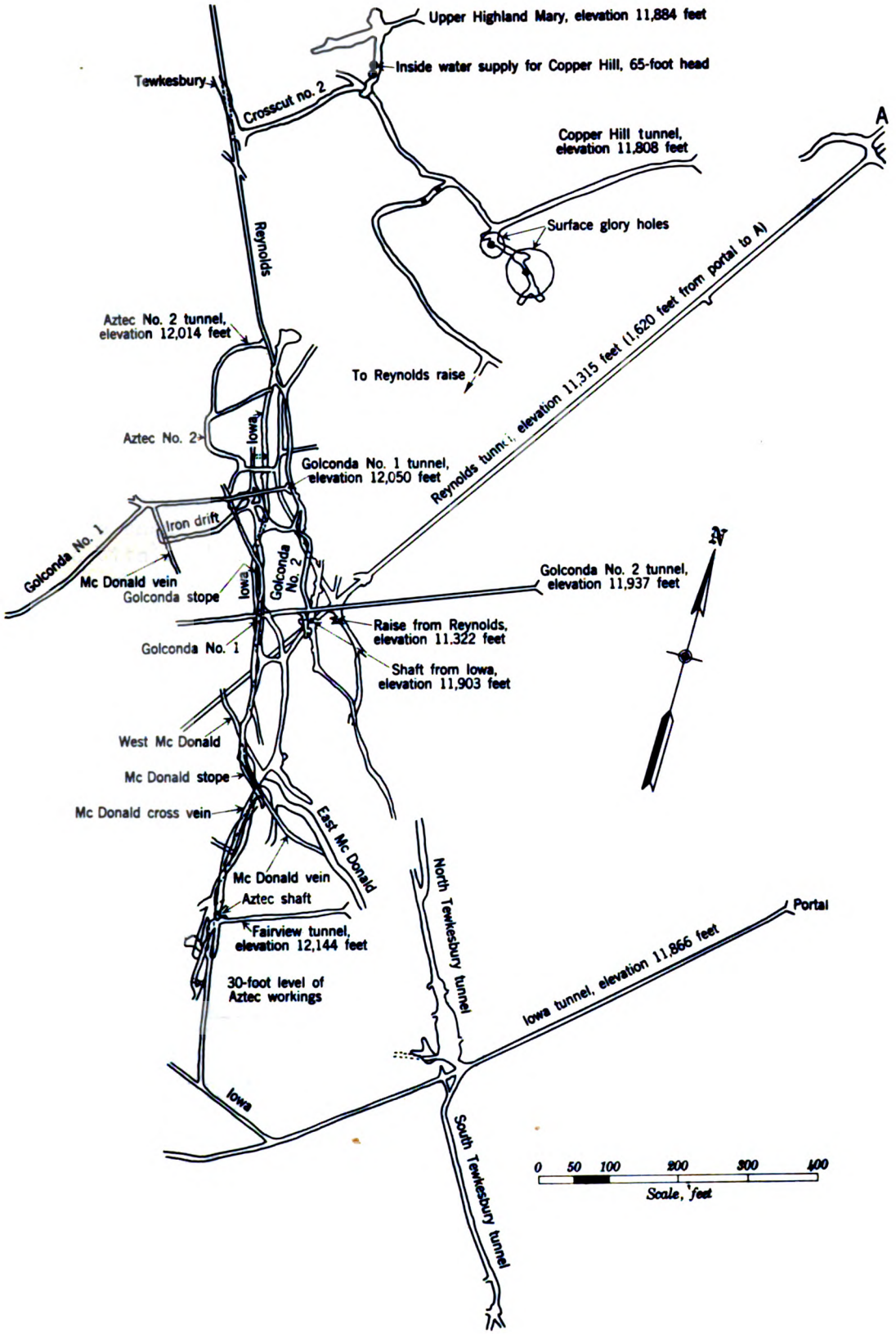

Figure 3.—Underground workings active in August 1937, at Summitville Consolidated Mines, Inc., Summitville, Colo.

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A 4-inch line carries compressed air to the mill.

The compressor man does the repair work on the air drills.

Air for the Iowa workings is supplied by a compressor at the portal of the Iowa adit. It is driven by a 150-horsepower motor and delivers air at 95 pounds pressure to a 4- by 12-foot receiver at the portal. A 4-inch air line extends into the adit. There is a 3- by 8-foot receiver 600 feet in the adit and a 4- by 12-foot receiver, 1,700 feet farther in, also a 4- by 10-foot receiver in a sublevel 150 feet above the adit. The compressor at the Iowa portal will soon be moved to the compressor building at the Reynolds portal.

The machine shop on the Reynolds dump contains the following equipment: A portable electric welding outfit, a 10-foot lathe, an electrically operated steel saw, an electric drill press, a shaper, a threading machine, two blacksmith forges, an electric steel-heating furnace, an air-operated drill-steel shaper, an air hammer, a grinder for taking the burr off the shank end of drill steel, and four grinding wheels (two for detachable bits). An electrician's shop adjoins the machine shop. Upstairs is a sheet-metal shop and a carpenter shop. The building is heated in winter by hot air from a central furnace. Just outside the building is a portable compressor unit; it was not in use in August 1937.

The company owns and operates a sawmill about 6 miles north of Summitville.

Underground Workings

The Summitville Consolidated Mines, Inc., operates three separate groups of underground workings, each group through its own adit; development completed as of August 1937 comprised the following (see fig. 3):

1. Reynolds workings: A crosscut adit 3,300 feet long; 300 feet of drifts in the Tewkesbury vein; 250 feet of crosscuts; a raise to the Iowa level (in progress).
2. Copper Hill workings: A crosscut adit 300 feet long; a 500-foot crosscut to intersect the Reynolds-Iowa raise (in progress); 1,000 feet of other crosscuts and drifts; 450 feet of raises.
3. Iowa workings: A crosscut adit 400 feet long to the Tewkesbury vein; 1,650 feet of drifts on the Tewkesbury vein; 1,100 feet of crosscuts to the McDonald vein; 200 feet of crosscuts to the Black Wonder vein; 600 feet of drifts on the Black Wonder vein; a raise 90 feet long to the Aztec level; 200 feet of drifts on the Aztec level. In addition, the following, which are reached through stopes:

   60 feet above the Iowa level: Golconda No. 2 level, consisting of 400 feet of drifts and 400 feet of crosscuts;
   150 feet above the Iowa level: Golconda No. 1 level, consisting of 800 feet of drifts.

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In August 1937 the following work was being done (see fig. 3):

1. Reynolds workings: Raise to Iowa level.

2. Copper Hill workings: Drifting on Hidden vein to connect with Reynolds raise between Reynolds and Iowa levels. Stope development on Hidden vein, consisting of driving six chute raises and erecting chutes. Drifting from a raise preparatory to stope development between the Copper Hill and Highland Mary levels. Mining in two glory holes, one of which was just being started.

3. Iowa workings: Open stoping on the McDonald vein. Stoping at three places on the Golconda No. 1 level, 150 feet above the Iowa level: an open stope 20 feet long, up 70 feet, worked by one miner and helper; a shrinkage stope 110 feet long, up 35 feet, worked by two miners, one timberman, and two timberman helpers; another shrinkage stope on the McDonald cross vein, 85 feet long, up 75 feet, worked by one miner, one timberman, and one timberman helper. Stoping on the Golconda No. 2 level, 60 feet above the Iowa level: a shrinkage stope (Aztec No. 2) 30 feet long up 60 feet, worked by one miner and a helper. Extending an old stope between the Golconda No. 1 and Golconda No. 2 levels, using one miner and a helper and occasionally a timberman.

Prospecting and Exploration

The work of drifting is interrupted occasionally to drive short crosscuts into the footwall and hanging wall. Feeders are sometimes followed out of stopes.

Occasionally exploration is done by drifting followed by raising; the Reynolds raise that was being driven in August 1937 from the Reynolds level to the Iowa level is mainly for exploration. This raise was following a vein, the average dip of which is 82°; the length of the completed raise will be about 600 feet. A 100-foot raise from the Dexter level to the New French level was completed in August 1937; it was driven for exploration.

Prospecting and exploration are done under the supervision of the geologist. Every summer there is extensive sampling of old workings and of the surface by channel sampling.

Samples are cut at 5-foot intervals along drifts and raises, and face samples are cut after every round. Stope samples are cut from the back of stopes after every round.

The sampling crew usually consists of five samplers; all report to the geologist. Sampling results are recorded on an assay map.

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Development

Considerable underground development work was done in the summer of 1937 to have stopes available in the winter that could produce enough tonnage to serve in lieu of the ore mined in the gloryholes during the summer. Four stopes had been prepared for production in the Copper Hill workings and six in the Iowa workings. In addition, five shrinkage stopes in the Iowa workings had been finished and were ready to be drawn; the largest stope was said to contain about 20,000 tons of broken ore.

Drifting

Adits are timbered for about half their length; the section is 6- by 6-feet inside the timbers. Sets usually are of 12- by 12-inch timbers; some are of round timbers about 10 inches in diameter.

Most drifts and crosscuts are driven 6- by 7-feet in section; about two-thirds of their length is timbered. Drills are mounted on either a horizontal bar or a vertical column; all drilling is done wet with detachable bits.

A drift on the Hidden vein in the Copper Hill workings was being driven in August 1937; it was the only place where two shifts a day worked. A machineman and helper drilled and shot a round of 12 holes on each shift. A bottom cut of three holes was used with three lifters, three breast holes, two back holes, and a relief hole just above the central cut-hole. Drilling was done with a drifting machine mounted on a horizontal bar. Starting bits were 2-3/8 inches; following diameters decreased by 1/4-inch; finishers were 1-5/8 inches. Shanks were made of 1-1/8-inch hollow round steel. Starters were 31 inches long; following shanks increased by 16-inch lengths. The air hose used was 1-1/2 inches inside diameter; the water hose, 1/2-inch. A small pressure tank at the face supplied water to the drills. Holes were loaded with 4 to 6 sticks of 1-1/8-inch 40-percent-strength gelatin dynamite per hole; two 50-pound boxes containing from 100 to 110 sticks each were required for three rounds. Number 6 blasting caps were used. Fuse was cut to 6-foot lengths and spit with a carbide lamp or fuse spitter. The average advance per round was from 3-1/2 to 4 feet; 11 rounds in August 1937 broke 48 feet.

The machineman and his helper put in pipe and laid track. Rails were 16-pound and the track gage was 26 inches. Mucking was done by an air-operated mechanical loader with a crew of two men - an operator and a helper. The loaded cars were pushed by hand to the nearest switch; from there they were hauled by a mule about 900 feet to the Copper Hill portal. One car was hauled at a time and dumped at the surface for ore or waste by the mule driver. A round was loaded out in 3-1/2 hours. The drift is timbered with 10- by 10-inch sets on 5-foot centers. The bottoms of caps are 7 feet above grade. Collar braces are 6-inch round timber. Poles 3 to 6 inches in diameter are used for lagging the top and sides of the sets.

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Raising

The raise from the Reynolds level to the Iowa level has a cross section 21 by 7 feet; it was being advanced at the rate of about 60 feet a month. The company pays a bonus of 50 cents per man for each foot of advance over 60 feet per month. A round consisted of 44 to 48 holes and broke about 12 feet. The entire face was drilled at one time, but only half was blasted at a time. About five sticks of 40-percent-strength gelatin dynamite were used in each hole. It took 7 hours to drill a round with two stopers, one machineman, and a helper to each machine.

Detachable bits were used with 1-1/8-inch hexagonal steel; starters were 2-7/8 inches in diameter. An air-operated pump supplied water to the drills from the drainage ditch.

The raise is divided into four compartments. The two end compartments are used for ore passes and are provided with chutes at the bottom; 12- by 12-inch dividers, lagged, separate them from the inside compartments. Dividers are set in hitches where the walls are hard; otherwise they are set against headboards. The two inside compartments are separated from each other by 10- by 10-inch dividers; one is used for a manway and is provided with 16-foot ladders; the other is provided with a slide and a small air hoist for raising timbers. Broken rock from the raise is loaded through chutes into 1-1/2-ton cars that are hauled out to the waste dump in 10-car trains by an electric locomotive. The raise is ventilated by a 3,000-cubic-foot blower; 10-inch tubing (some of it metal and some canvas), conveys the air to the face.

Sinking is done only for the purpose of completing connections with raises.

Mining Methods

Three stoping methods are used - shrinkage and open stope underground and the gloryhole method on the surface.

Underground stopes range from 3 to 20 feet in width. Shrinkage stopes are used in ground that stands well. In narrow veins and where the walls slough badly stopes with safety grizzlies are used. The gloryhole method was being used in a wide section of the vein above the Copper Hill adit.

Shrinkage Stopes

Shrinkage stopes are started by driving 6- by 6-foot chute raises at intervals of about 25 feet along the drift. The raises are driven on the vein for a height of about 8 feet and chutes 4 feet wide are built at the bottom. They are then branched in both directions along the vein at a slope of 45° to connect; the branches take the full width of the vein. Chute raises at the ends of the stope are broken 11 by 6 feet to allow for a manway compartment at the extreme end of the stope. The backs

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of the stopes are carried flat and are broken by stoper rounds. The cut is started by extending the end raises one round ahead of the stope. The manway is then bulkheaded and stope holes are drilled to break to the raise. Mining proceeds from the raise at one end of the stope to the raise at the other end. Most stopes are between 50 and 200 feet in length; the usual height is 180 feet. If the length of the stope is great, several slices may be in progress at the same time. A stope crew consists of two machinemen, one timberman, and two timberman helpers. Vertical holes 5 feet deep are drilled in the back with a wet stoper; each miner drills about 20 holes in a shift. Three to four sticks of 40-percent-strength gelatin dynamite are used in each hole. About 3 tons of ore are broken per hole. Two-thirds of the ore broken in the stope is left for support of the walls and as a working floor for the next cut; the other third is drawn from the chutes in such a manner as to keep the top of the broken ore in the stope fairly level. Occasionally a stull with headboard is used to hold a weak part of the walls.

Miners carry their own rods and bits to and from the portal of the workings. A service truck takes worn steel to the shop and delivers sharp steel to the portals.

Timbermen take in timber from the yard at each portal.

Open Stopes

Open stopes are started by driving 6- by 6-foot chute raises at 25-foot intervals along the drift, as in the case of shrinkage stopes. Manways are lagged off at the ends of the stope. The ore is broken as in the shrinkage stopes previously described. Six- to 8-inch stulls are used to support the walls, and safety grizzlies, consisting of 8-inch round holes, are carried on the stulls about 20 feet below the miners and are carried ahead as the stope advances. The grizzly serves as a safety measure and to break the fall of ore into the chutes. The average height of the open stopes is about 100 feet. Occasional patches of lean vein material are left as pillars.

Gloryholes

Ore is mined in two gloryholes above the Copper Hill adit (see fig. 3). The larger was started from a raise from the adit level which broke to the surface at a height of 140 feet above the level. The top of the raise was funneled out and in August 1937 was 75 feet across at the top. Two miners produced 60 tons of ore a day, mainly by mud capping and picking. A jackhammer was used occasionally, but most of the large boulders were blasted with a stick to a stick and a half of 40-percent-strength gelatin dynamite placed as a mud shot.

The other gloryhole was about to begin production in August 1937. It was started from the top of an old shaft 40 feet deep into the bottom of which a raise from the adit level had broken. The total height from

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the adit to the surface is 115 feet. A miner was using a jackhammer to funnel out the top of the hole. He drilled about 12 holes 5 feet deep in a day and used about 6 sticks of 40-percent-strength gelatin dynamite per hole.

Ventilation and Drainage

Ample air is supplied to practically all the underground workings by natural ventilation, due to the distribution of mine openings over a relatively great vertical range. The raise from the Reynolds to the Iowa level is the only place that requires mechanical ventilation. In August 1937 the raise was ventilated by a 15-horsepower blower on the Reynolds level (see p. 10).

Mine workings are generally dry; most of the water used for drilling must be piped in from the camp supply.

Transportation

In August 1937 the company had three 3-1/2-ton storage-battery locomotives - one at the Reynolds adit, one at the Iowa adit, and a third that was being repaired at the Reynolds shops for use in the Copper Hill adit. Charging stations are located underground at the Reynolds and Copper Hill workings; the Iowa station is at the portal. Adits are equipped with 30-pound or 16-pound rails; the gage is 26 inches.

Ore and waste were hauled out of the Reynolds adit in trains of 1-1/2-ton cars (see p. 10). The ore was hauled to the mill bins and the waste to the dump.

At the Copper Hill workings a mule hauled the ore out to the portal in 1-ton end-dump cars (see p. 9). The ore was dumped into a 10-ton hopper-shaped bin, from which it was loaded through chutes into trucks. High-grade ore was dumped through a 3-inch grizzly into a small hopper, from the bottom of which an 18-inch sheet-iron pipe conveyed it to a separate 5-ton bin at the roadway. Two 5-ton trucks were used to haul ore from the Copper Hill bins to the mill bins. Waste from the Copper Hill workings was also hauled out by a mule.

At the Iowa workings the locomotive hauled out ore and waste in trains of 1-1/2-ton cars. Waste was dumped near the portal and ore was dumped into the loading bin of an aerial tramway. The tramway is about half a mile long; the drop from the Iowa portal to the mill is about 550 feet. Buckets holding 600 pounds delivered the ore to the mill bins. The aerial tramway is used only for transporting ore, except during severe winter weather when it becomes impossible to keep the roads open. At such times the tram is used to transport supplies and passengers as well as ore.

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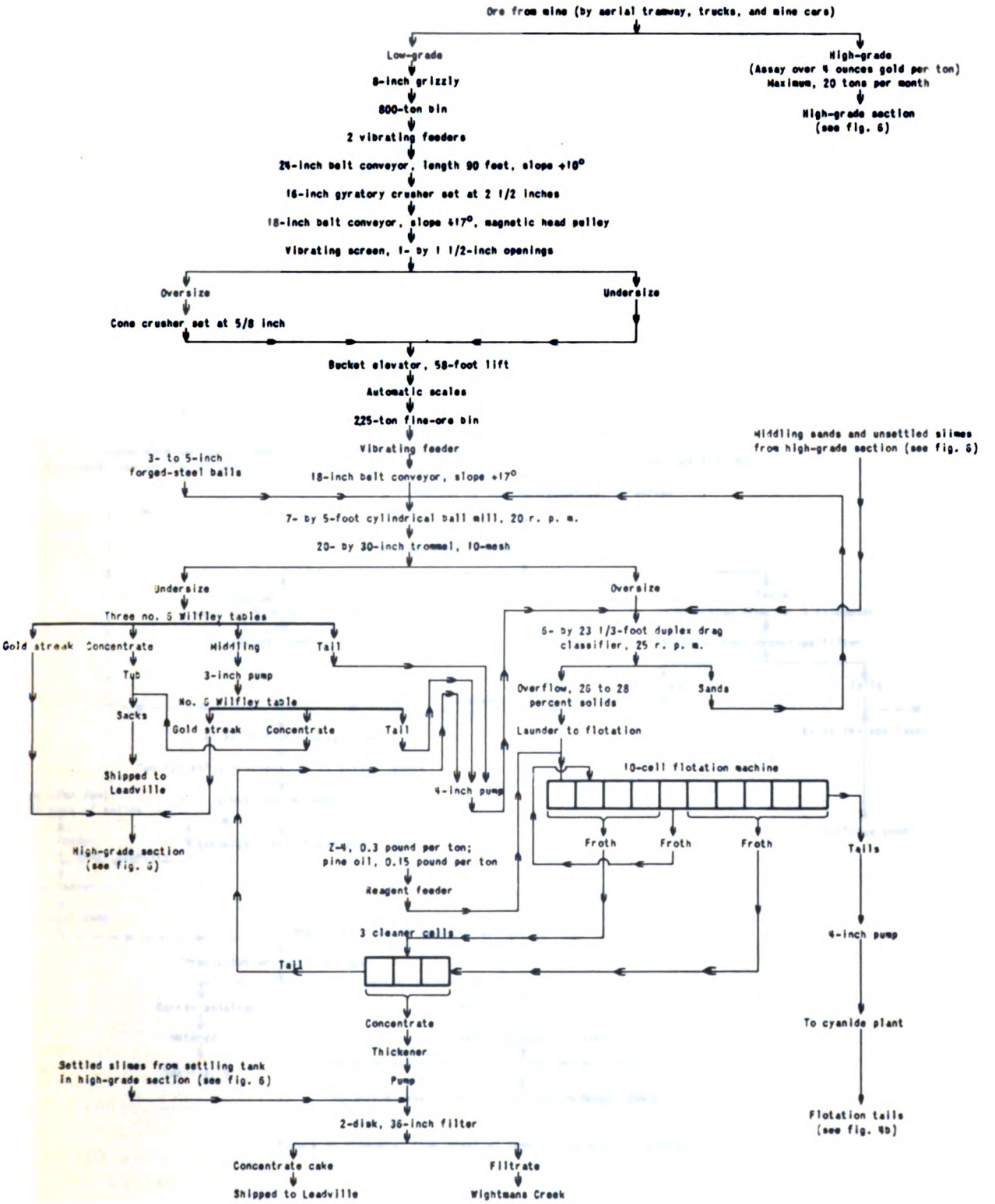

Figure 4a.- General flow sheet of Summitville mill (average monthly tonnage, 3,000).

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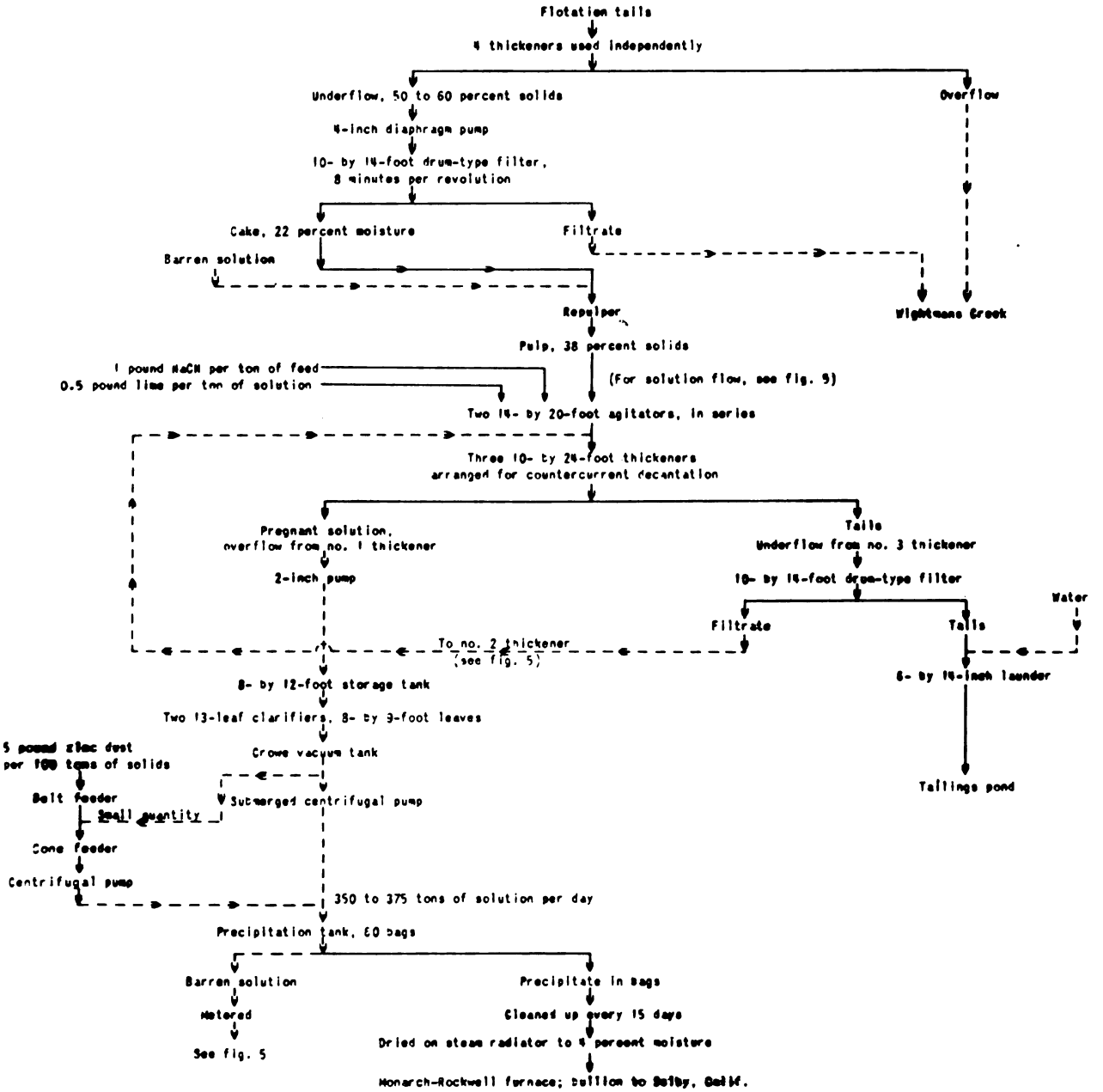

Figure 46.- General flow sheet of Summitville mill (continued).

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All portals are connected with one another and with the main townsite by fairly good dirt roads.

Underground chutes used for loading 1-1/2-ton cars are 4 feet wide; they have board gates. The lower board slides in a slot formed by a 1-1/2-inch round iron bar on each side of the chute. The upper boards are in slots in the sides of the chute. Other underground chutes are not standardized; they are usually narrower and equipped with conventional board gates.

Mining Costs

In August 1937 the following wage scale was in effect at the mine:

	Daily wage scale, August 1937
Foreman	$6.00
Shift boss	5.00
Stope bosses	4.75
Machinemen	4.25
Timbermen	4.50
Mule drivers	3.75
Machinemen helpers	3.50
Timbermen helpers	3.50
Muckers and trammers	3.50

Men worked 6 days a week at all portals. There was an 8-hour day shift at each portal and an 8-hour night shift at the Copper Hill workings for development.

Mining costs for the first 6 months of 1937 are shown in table 2; they cover an average monthly mined tonnage of 3,250 tons. Monthly development during the period averaged approximately 400 feet of drifts.

MILL

General Features

The mill of the Summitville Consolidated Mines, Inc., is in the main camp at Summitville; its location is shown in figure 2a. It is of the side-hill type and has a capacity of 100 tons per day. The milling method used for most of the ore is a combination of gravity concentration and flotation followed by cyanidation of tails; the general flow sheet is shown in figures 4a and 4b.

High-grade ore is treated in a separate section of the mill, as described later (see p. 18).

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TABLE 2. - Underground costs per ton of ore produced, first half of 1937

	Labor	Supervision	Compressed air, drills, and steel 1/	Explosives	Timber	Other supplies	Shop	Assays	Total
Development...	2/ $0.620	$0.079	$0.390	$0.171	$0.037	$0.046	$0.016	$0.022	$1.381
Mining.....	3/ .852	.094	.672	.228	.082	.028	.024	.056	2.036
Transportation	4/ .297	-	-	-	-	.078	-	-	.375
Total....	1.769	.173	1.062	0.399	.119	.152	.040	.078	$3.792

1/ Includes labor and supplies used in operating compressors, laying air and water lines, repairing rock drills, and sharpening steel; also includes all mine power.
2/ Development labor includes miners, shovelers, and timbermen engaged in driving drifts, crosscuts, raises, and winzes.
3/ Includes those employed in stopes, up to the delivery of the ore to the haulage system.
4/ Includes locomotive crews, mule drivers, and trammers engaged in hauling ore and waste to the several portals.

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The present practice was adopted as a result of tests, and because earlier attempts to amalgamate the ore had failed to recover rusty gold and gold locked up in sulphides.

Water for milling is obtained from the camp supply (see p. 5). No water is reclaimed in summer. Springs sometimes freeze in February if not enough snow has fallen to protect them. At such times as much as 50 percent of the water used may be reclaimed; this is done at a group of thickeners preceding cyanidation.

Ore from the gloryholes is hard; most ore from underground workings is of medium hardness, but some is talcy. The gold is finely disseminated in a gangue of quartz and silicified quartz-latite (see p. 4). The average gold content of the ore for the 12 months ended July 31, 1937, was 0.40 ounce per ton; moisture was about 5 percent.

Milling Method

Gravity

Ore is brought to the mill from the Reynolds portal and the Copper Hill workings via the transfer raise completed in January 1938 and tunnel by electric trains, and from the Iowa portal by aerial tramway. All the ore is dumped upon a grizzly of inverted railroad rails spaced 8 inches apart. A few oversize boulders are sledged through and join the undersize in an 800-ton bin. Two vibrating feeders below the bin deliver the ore to a 24-inch belt conveyor that carries it 90 feet up a 10° slope to a 16-inch gyratory crusher. The conveyor is driven by a 5-horsepower motor, the crusher by a 60-horsepower motor. Coarse crushing is done only on night shift; 100 to 110 tons of ore are crushed in about 6 hours. The crusher makes a 2-1/2-inch product that is taken up a 17° slope by an 18-inch belt conveyor. A magnetic head pulley removes tramp iron. The conveyor is driven by a 7-1/2-horsepower motor; it delivers the ore to a vibrating screen having 1- by 1-1/2-inch openings. The screen is driven by a 3-horsepower motor. The oversize drops into a cone crusher driven by a 75-horsepower motor. The 5/8-inch product of the crusher and the screen undersize are raised 58 feet by a bucket elevator. A 5-horsepower motor drives the elevator. The ore is delivered to an automatic weighing device that registers every 400 pounds. It then drops into a 225-ton fine-ore bin. A vibrating feeder delivers the fine ore to an 18-inch belt conveyor that carries it up a 17° slope to the feed box of a 7- by 5-foot cylindrical ball mill. A 200-horsepower, 2,300-volt motor drives the ball mill at 20 r.p.m. The ball load is 8 tons of 3- to 5-inch forged-steel balls; 4 to 5 pounds are consumed per ton of ore. The liners are of manganese steel; a set lasts 6 to 8 months. The circulating load is 100 to 150 percent and the pulp contains 72 percent solids. The discharge end of the ball mill is equipped with a 24- by 30-inch trommel with a 10-mesh screen. The trommel oversize passes to a duplex drag classifier 6 feet wide and 23 feet 4 inches long. The sands from the

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classifier are returned to the ball mill; the overflow, containing 26 to 28 percent solids, goes to flotation. The undersize from the ball-mill trommel is conveyed in a launder, which branches to feed three Wilfley tables. Each table is driven by a 1-1/2-horsepower motor. The tables make four products - a gold streak, a concentrate, a middling, and a tail. The gold streaks are treated in the high-grade section of the mill described on page 18; the concentrates are caught in a tub, shoveled into sacks, and shipped to the American Smelting & Refining Co. at Leadville, Colo.; the tails are pumped up to the classifier by a 4-inch centrifugal pump driven by a 20-horsepower motor. A 3-inch centrifugal pump driven by a 10-horsepower motor pumps the middlings to a fourth table, which makes a gold streak, a concentrate, and a tail. These products are combined with the corresponding products from the three tables immediately preceding. The gravity concentration just described removes coarse gold and concentrates, thus relieving the ball mill and the subsequent treatment of slimes by flotation and cyanidation. Table 3 shows the screen sizes of the mill heads, ball-mill feed, ball-mill discharge, and classifier overflow.

TABLE 3. - Screen sizes of heads and mill products, percent

Screen size	Mine run, 150-lb. sample	Ball-mill feed[1]	Ball-mill discharge	Classifier overflow[2]
+2-inch.....	35.21	-	-	-
-2 +1.....	15.89	44.00	-	-
-1 +1/2.....	15.10	26.49	-	-
-1/2 +3-mesh..	8.71	10.73	-	-
-3 +4.....	3.20	3.30	-	-
-4 +6.....	2.94	2.42	-	-
-6 +10.....	5.00	2.98	4.72	-
-10 +14.....	1.80	1.06	1.49	-
-14 +20.....	1.44	.86	1.58	-
-20 +28.....	1.24	.77	2.28	-
-28 +35.....	1.06	.69	3.57	-
-35 +48.....	.79	.56	5.60	-
-48 +65.....	.70	.48	8.90	.38
-65 +100.....	.94	.69	14.50	6.42
-100 +150.....	.62	.42	8.37	9.23
-150 +200.....	.75	.48	8.44	12.63
-200.....	4.61	4.07	40.55	71.34
	100.00	100.00	100.00	100.00

1/ Average result with cone crusher set at 1-1/2 inches.
2/ Represents feed to flotation and approximatesfeed to cyanide plant.

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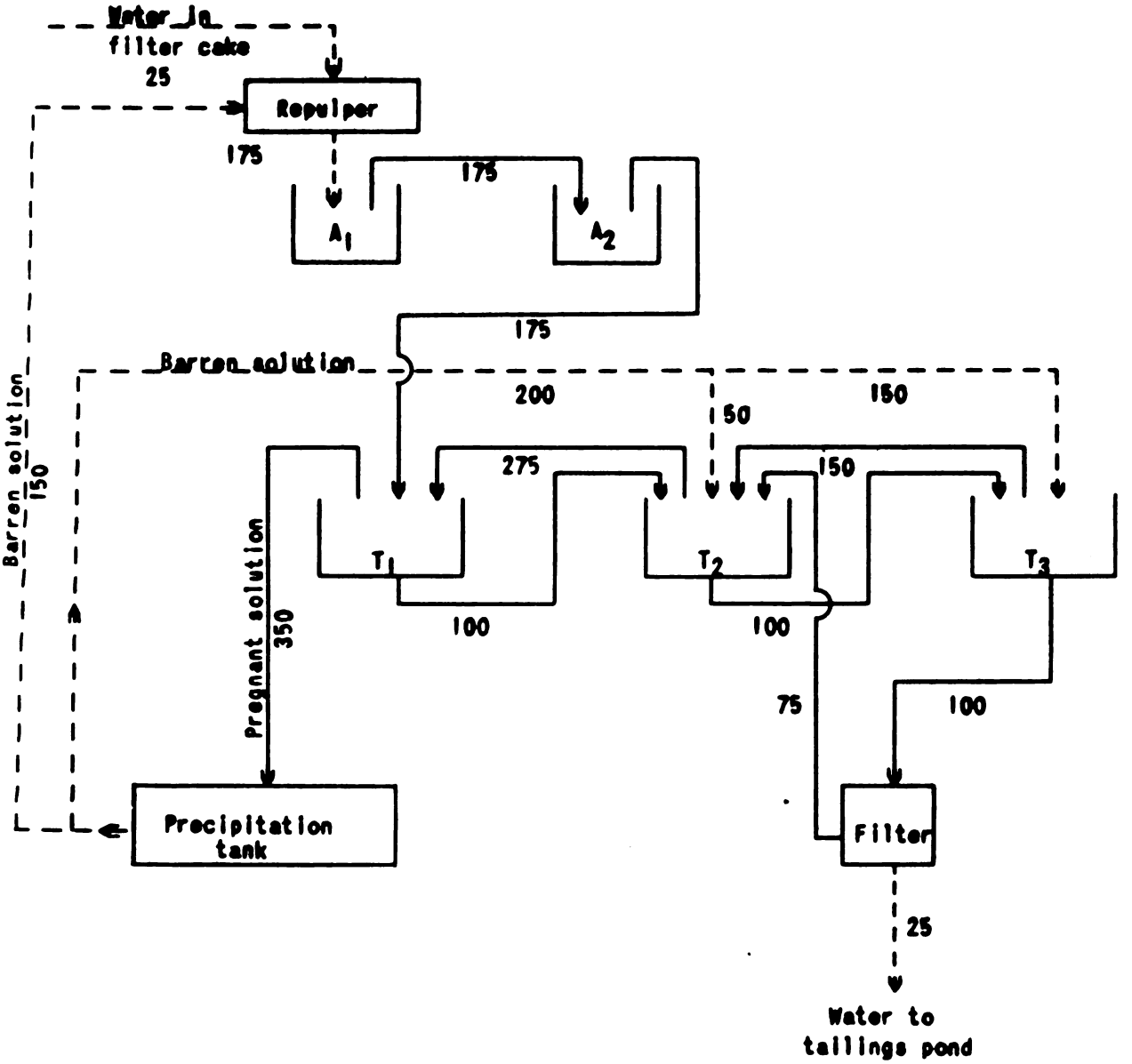

Figure 5.- Solution flow sheet of cyanide plant. Numbers represent tons of solution per day.

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Flotation

The classifier overflow is conveyed in a launder to a 10-cell flotation machine. A reagent feeder of the revolving-cup type feeds 0.3 pound of Z-4 and 0.15 pound of pine oil per ton of ore into the launder just ahead of the machine. The cells are 24 inches wide; five 5-horsepower motors drive the impellers. The feed enters the first cell. The first four cells make a concentrate; the product of the fifth cell is returned to the second cell; the last five cells make a concentrate. The concentrate from the first four cells enters the middle cell of a bank of three cleaner cells; the concentrate from the last five cells of the larger machine enters the first cleaner cell. The tails from the 10-cell machine are pumped by a 4-inch centrifugal pump to an all-slime cyanide plant. The pump is driven by a 20-horsepower motor. The tails from the cleaner cells are pumped back to the classifier by the same 4-inch pump that handles the tails from the tables. The cleaner concentrates are thickened and pumped to a 2-disk 36-inch filter. The pump and filter are driven from a line shaft by a 7-1/2-horsepower motor. The filtered concentrate is shipped in bulk to the American Smelting & Refining Co. at Leadville. The filtrate flows into Wightmans Creek.

Cyanidation

The main purpose of the cyanide plant is to recover the gold in the oxidized ores that is not recovered by flotation. The tails from the 10-cell flotation machine are pumped into a group of four thickeners, which are used independently. Two of the thickeners are 8 by 24 feet; one is 8 by 20 feet; one is 10 by 24 feet. The revolving arms in each of the first two thickeners are driven by a 1-1/2-horsepower motor; each pump by a 1-horsepower motor. The other two thickeners and their pumps are driven from a line shaft by a 5-horsepower motor. The thickeners overflow into the creek. The underflow, containing 50 to 60 percent solids, is pumped by 4-inch diaphragm pumps to a 10- by 14-foot drum-type filter. The filter makes one revolution in 8 minutes; it is driven by a 3-horsepower motor. The filtrate is pumped into the creek. The filter cake, containing about 22 percent moisture, is repulped with cyanide solution to about 38 percent solids. The repulper is driven by a 1-horsepower motor. The pulp is delivered to the first of two 14- by 20-foot agitators in series. One pound of sodium cyanide per ton of solid feed (to cyanide plant) and one-half pound of lime per ton of solution are added in the agitators. Iron sulphate consumes some alkali; most of the copper is removed by flotation. Aeration is effected in the agitators by air lift; the air is supplied by a rotary compressor driven by a 15-horsepower motor. The revolving arms of the agitators are driven at 4-1/2 r.p.m. from a line shaft by a 7-1/2-horsepower motor. The total treatment period is about 24 hours. The pulp passes from the agitators to the first of a series of three 10- by 24-foot thickeners arranged for counter-current decantation. The solution flow sheet of the cyanide plant is shown in figure 5. The thickener arms and the diaphragm pumps are

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driven from a line shaft by a 7-1/2-horsepower motor. The pregnant solution overflowing from no. 1 thickener (and occasionally some from no. 2 thickener) goes to precipitation. The underflow from no. 3 thickener is filtered in a 10- by 14-foot drum-type filter. The filter cake is not washed; it is flushed through a 6- by 14-inch launder to the tailings pond with water from the Reynolds adit. The filtrate is pumped to no. 2 thickener; the filtrate pump is driven by a 5-horsepower motor.

The pregnant solution from no. 1 thickener contains about 0.032 ounce of gold per ton. It is pumped by a 2-inch centrifugal pump to an 8- by 12-foot storage tank. A 3-horsepower motor drives the pump. From the storage tank the gold solution flows to two 13-leaf clarifiers; the leaves are 8 by 9 feet. The clear solution is de-aerated in a Crowe vacuum tank. A submerged centrifugal pump driven by a 3-horsepower motor pumps the solution to a precipitation tank. Zinc dust is fed by a small belt feeder into a cone that is supplied with gold solution from the vacuum tank; a small centrifugal pump driven by a 1-horsepower motor delivers the mixture to the gold-solution line just ahead of the precipitation tank. Five pounds of zinc dust are used per 100 tons of solids in the cyanide-plant feed. From 350 to 375 tons of pregnant solution are precipitated per day. The precipitation tank contains 60 double bags - a piquet bag within a canvas bag. The gold is precipitated in the bags. The barren solution is metered as it overflows from the tank; it is delivered to storage by a centrifugal pump driven by a 3-horsepower motor. The precipitate in the bags is cleaned up every 15 days. The bags are allowed to dry 8 hours and are then put through a wringer which squeezes about 80 percent of the precipitate out of the bags and into a pan. The bags are then turned inside out and put through a standard domestic washing machine. The precipitate is collected and then dried on a steam radiator to about 4-percent moisture, reduced to bullion in a Monarch-Rockwell furnace, and the product shipped to Selby, Calif.

Mill production data for the second quarter of 1937 are given in table 4; the figures represent monthly averages during that period. A monthly average of 3,600 tons of ore was milled during the period.

The costs of mill reagents and grinding balls consumed in the first 9 months of 1937 appear in table 5.

High-grade Section

The high-grade section of the mill is used intermittently to treat a small tonnage of ore that assays over 4 ounces of gold per ton. High-grade ore from the Iowa workings is delivered to the mill in sacks via the aerial tramway; high-grade ore from the Copper Hill workings is hauled to the mill in trucks. The capacity of the high-grade section is about 5 tons per shift; the maximum tonnage ever treated in one month was 20. Figure 6 is a flow sheet of the high-grade section of the mill.

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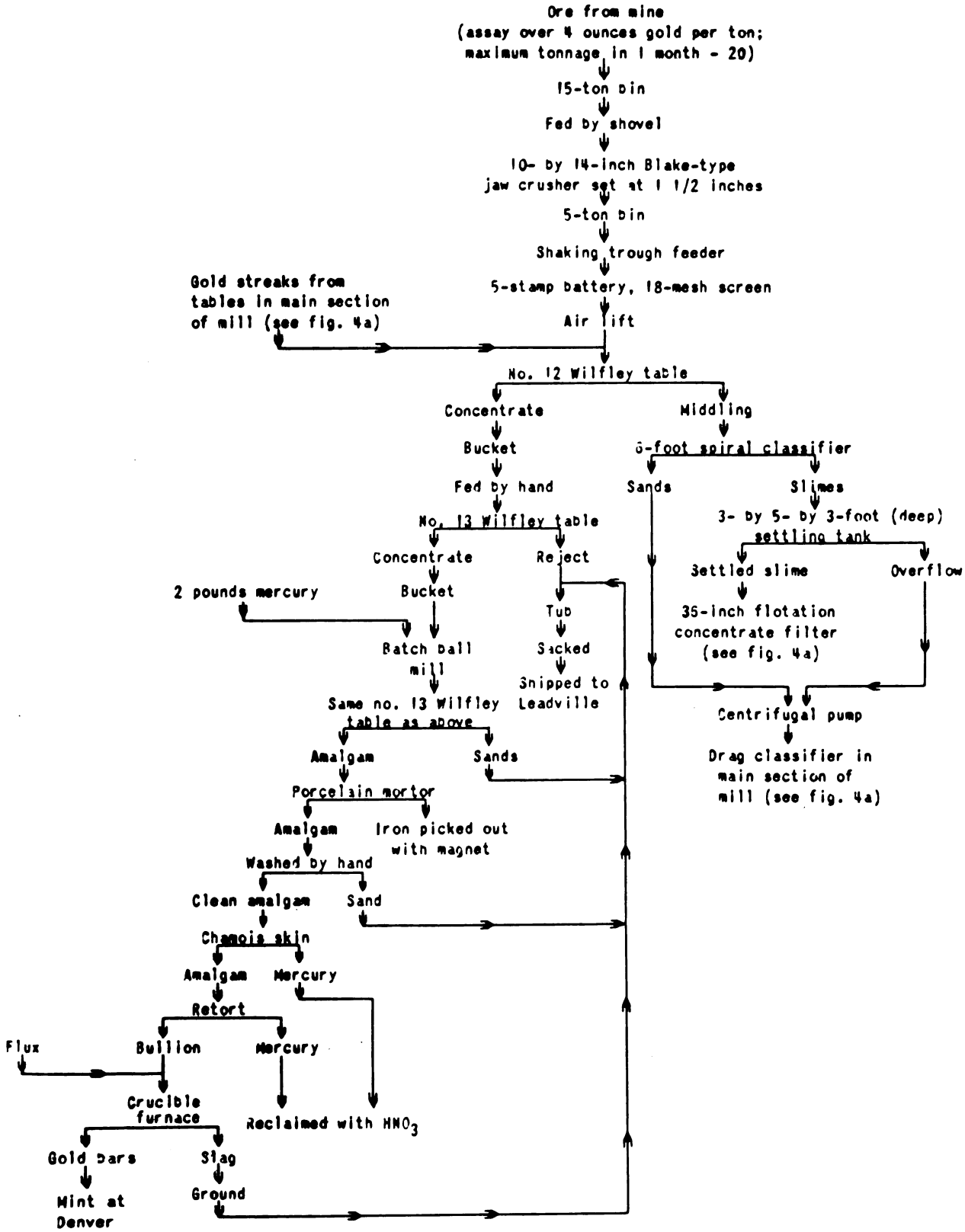

Figure 6.- Flow sheet of high-grade section of mill.

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TABLE 4. - Average monthly mill production data for second quarter of 1937

Mill product	Tons	Gold content		Recovery		Losses	
		Oz. per ton	Ounces	Ounces	Percent	Ounces	Percent
Mill heads	3,600	0.366	1,319.70	-	-	-	-
Bullion from table concentrates	-	850 fine	120.00	120.00	9.09	-	-
Table concentrates (after removal of bullion)	30	6.500	195.00	195.00	14.78	-	-
Table tails; flotation heads	3,570	.282	1,004.70	-	-	-	-
Flotation concentrates	150	3.500	525.00	525.00	39.78	-	-
Flotation tails; cyanide heads	3,420	.140	479.70	-	-	-	-
Cyanide precipitates	0.18	2,000.000	360.00	360.00	27.28	-	-
Cyanide tails	3,420	.035	119.70	-	-	119.70	9.07
Total				1,200.00	90.93	119.70	9.07

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TABLE 5. Costs of mill reagents and grinding balls, 1937

Month	Flotation reagents, cost per ton of head ore	Grinding balls, cost per ton of head ore	Cyanide reagents		Total cost per ton of head ore
			Cost per ton of head ore	Cost per ton cyanided	
January.....	$0.0732	$0.2631	$0.1625	$0.2614	$0.4988
February.....	.0935	.2360	.1835	.1959	.5130
March.....	.0777	.2600	.1822	.2457	.5199
April.....	.0739	.2780	.2110	.2760	.5629
May.....	.0721	.1411	.2356	.2664	.4488
June.....	.0536	.2319	.1908	.1975	.4763
July.....	.0956	.1434	.2445	.2538	.4835
August.....	.0654	.2051	.3382	.3492	.6087
September.....	.0490	.2248	.3580	.3699	.6318

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High-grade ore brought to the mill is dumped into a 15-ton bin, from the bottom of which it is shoveled by hand to feed a 10- by 14-inch Blake-type jaw crusher. The crusher is belt-driven at 300 r.p.m. by a 5-horsepower motor; it is set at 1-1/2-inches. The crushed ore drops into a 5-ton bin, from which a shaking trough feeder, driven from the crusher motor, feeds it to a battery of five stamps. The stamps weigh 750 pounds each; they fall 6-1/2-inches at the rate of 92 drops per minute; the order of drop is 1, 5, 2, 4, 3 - the California order. The bull wheel is driven by flat belt from a jack shaft, which in turn is driven by a 10-horsepower motor with V-belt drive. The crushed ore is discharged from the mortars through an 18-mesh wire screen and flows into a wooden box 9 inches square and 6 feet deep. An air lift equipped with a 1-inch air line and a 2-inch discharge line raises the pulp out of the box to feed a No. 12 Wilfley table. A small air compressor driven by a 3-horsepower motor supplies air for the lift at 20 pounds per square inch. The feed to the Wilfley table includes, in addition to the crushed high-grade ore from the stamps, the high-grade streaks from the Wilfley tables in the main section of the mill (see fig. 4a). The table makes 280 half-inch strokes per minute; it is driven by a 1-1/2-horsepower motor. A concentrate from the table, amounting to about 600 pounds per shift, is caught in a bucket. The rest of the table discharge is treated as a middling; it flows into a 6-foot spiral classifier driven by a 1-horsepower motor. The slimes from the spiral classifier overflow into a rectangular 3- by 5-foot settling tank 3 feet deep. The overflow from the tank and the sands from the spiral classifier are pumped to the drag classifier in the main section of the mill. The slimes that settle out in the rectangular tank are filtered with the thickened flotation concentrate in the main section.

The table concentrate in the bucket, referred to above, is fed by hand to a No. 13 Wilfley table. This table is driven at 320 strokes per minute by a 1/4-horsepower motor; the stroke is 1/4-inch. The small table makes about 70 pounds of concentrate per shift. The reject is caught in a tub, sacked, and shipped to Leadville. The concentrate is transferred in a bucket to a small batch ball mill, which is used as an amalgamator. The ball mill is driven at 50 r.p.m. by a 1-horsepower motor; it uses 3- to 6-inch balls. The charge is ground with 2 pounds of mercury for about 12 hours. The product from the mill is then treated on the no. 13 Wilfley table just described. The amalgam is drawn off into a porcelain mortar, where the iron is picked out with a magnet. The sands are caught in the reject tub mentioned above. The amalgam is washed by hand and the mercury pressed out through a chamois skin. The amalgam is then retorted and melted in a gas-fired crucible furnace with a flux of borax glass, niter, and soda ash. The resulting bullion is about 850 fine with about 6 to 7 parts of gold to one of silver; a little copper is present. Bullion is cast in 30-ounce bars; that weight was adopted because the maximum insurance on first class registered mail is $1,000. Bars are mailed to the mint at Denver. The slag is ground and added to the sands in the reject tub of the No. 13 Wilfley table. Mercury from the press and from the retort condenser is reclaimed with nitric acid; the loss is insignificant.

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Tailing disposal

Mill tailing is impounded in Wightmans Gulch by a series of dams; there are three just below the mill, and four more down the creek within a mile. Alum Creek enters the Alamosa River about 4 miles above the mouth of Wightmans Creek, and Iron Creek enters it about 2 miles farther up. Those two streams contaminate the water in the Alamosa to such an extent that further pollution from Wightmans Creek (that is, Summitville) is not important.

Milling Costs

Table 6 shows the distribution of milling costs per ton of ore milled during the second quarter of 1937. A monthly average of 3,600 tons was milled during the period.

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TABLE 6. - Milling costs per ton of ore milled, second quarter of 1937

Operation	Operating labor	Supervision	Power	Supplies			Reagents	Repairs		Assays	Heating	Total
				Main items	Miscellaneous	Lubricants		Labor	Supplies			
Crushing..	$0.081	$0.007	$0.052	-	$0.004	$0.001	-	$0.048	$0.113	$0.003	$0.004	$0.313
Grinding..	.076	.014	.342	1/ $0.136 2/ .083	.002	.001	-	.060	.057	.005	.004	.780
Tabling...	.101	.014	.052	-	.001	.002		.026	.030	.021	.006	.305
Flotation.	.040	.007	.024	-	.002	.002	$0.052	.016	.012	.005	.007	.115
Cyanidation	.183	.021	.287	3/ .191 4/ .046	.015	.009	.025	.169	.138	.056	.034	1.174
High-grade section..	.089	.007	.013	-	.002	.001	-	.028	.031	.004	.006	.181
Tailing disposal.	-	-	-	-	-	-	-	.076	.033	-	-	.109
Total	.570	.070	.770	.456	.026	.016	.077	.423	.414	.094	.061	2.977

1/ Grinding balls.
2/ Ball-mill liners.
3/ Cyanide.
4/ Lime.

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